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Autor: Todd

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Problems in Science Policy

Lord TODD (Cambridge)

My subject is a large one and I can touch only on certain aspects of it and then in a rather general way. "Science Policy" is a topic which has been widely discussed in recent years, but it is difficult to define it precisely. I believe it could best be defined as national policy for the promotion of science and technology on the one hand and for their application to promote desirable material and social change on the other. But why should it be so important today? Before discussing problems of scientific policy it might be well to try to answer this question and I believe the answer is to be found by looking back over the history of mankind. Man differs from other animal species by the way in which he can consciously change or control his environment by technology, which is simply the application of discovery or invention to practical use. This he has done from the earliest times when he fashioned his first tools or weapons; indeed even in pre-historical times it seems likely that the much more rapid evolution of man as compared, say, with the chimpanzee in the matter of brain development has been in part due to selection based on technological skills. In historical times, however, it is abundantly clear that man's progress, both material and social, has depended on advancing technology.

No doubt man's early progress was punctuated by failures and disasters for no advance, be it in agriculture or anything else, is free from risk. But, on the whole, successes outweighed failures and as his technology advanced so did his social organisation—from the family to the village and on through city state to nation, each step forward being associated with new or improved technology; consider, for example, the rise and fall of states and empires under the impact of improvements in military technology. Each new advance brought in its train social changes, but the pace of advance, although it gradually increased, remained on the whole slow until about the end of the eighteenth century when the Industrial Revolution began. For this there were doubtless many reasons, but I think that three stand out as being of major importance. Firstly, advances depended entirely on the exploitation of chance discovery or invention; secondly, man was short of mechanical power and had to depend too much on musclepower of himself or other animals; and thirdly, communications were so poor that it could take generations for a technological advance to

spread over any large areas of the world. The importance of these factors is very clear if one looks at the varying level of indigenous development in different parts of the world. But, although the pace and pattern of advance varied from time to time and from place to place, it was in most instances tolerable and only rarely did it cause violent social upheavals. It was, in my view, tolerable because in general it was slow, and did not demand revolutionary social or occupational changes within the span of one man's lifetime. Man, like all other animals, is essentially conservative; he seeks, above all, for stability within his own lifetime. This desire is reflected in the social system which he built up (albeit in various forms) over a long period; in that system the tradition of family was extended to include the hierarchical state and both were legitimised and fortified by religion and by a somewhat prejudiced presentation of history. Education was essentially a matter of apprenticeship in which the child learned from the father or other qualified craftsman a set of skills which, with virtually no change, was sufficient to carry him through his whole working life. This system provided the feeling of security and continuity which was felt necessary by society. It began to show signs of cracking in Europe early in the eighteenth century, however, when improvements in communications by sea began to reveal new lands and brought Europe into contact with societies and civilisations, which, although striving for similar security and stability, were based on somewhat different social practices. But it was the Industrial Revolution which really triggered the process of dissolution of the old system by destroying its stability. In the early phases the Industrial Revolution was no different from earlier advances in that it depended on the chance appearance of a number of inventions at about the same time. The invention of the steam engine, perhaps the most important feature of the Industrial Revolution since it placed almost unlimited mechanical power at man's disposal, had little or nothing to do with science. Science, it is true, had been advancing since the time of the so-called scientific revolution of the late seventeenth century, but it had remained an amateur pursuit making little impact on everyday life. The advent of the steam engine and a great array of mechanical devices led in due course to an enormous increase in the speed and ease of communications and a corresponding increase in the extent and nature of manufacturing industry. The rapidity with which these developments took place put an almost intolerable strain on existing societies which were basically organised to resist change, and unrest associated with the rise of an industrial proletariat was widespread by the middle of the nineteenth century. But this was only the beginning, for something new and vitally important occurred about the middle of the nineteenth century when men began to apply science and the results of scientific research to the solution of practical problems. As a result technological advance ceased to be wholly dependent on chance discovery or invention and it is this new, science-based technology which has been responsible for all the enormous changes in our material civilisation which have occurred since then—changes which have been and still are occurring at an ever-increas-

ing rate. The trouble we face today is that society has not changed at anything like the same rate and this is the real basis of much of the current social and political unrest in the world. The whole fabric of our society was designed to maintain stability and continuity and to resist change in the pattern of life. With the advent of rapid technological change the system has begun to break up; in particular faith in the tradition of family and, more especially, of religion which provided the cement holding together the various elements in society have been crumbling and no satisfactory substitutes have yet been found. But everywhere it is evident that economic strength and with it national stability are dependent on technological progress and it would be hard to think of any area of national or international affairs in which science and technology are not involved directly or indirectly. Under such circumstances it is clear that correct policy decisions can hardly be expected in a democracy whose members are ignorant of science; yet traditional educational patterns, which rest on social attitudes, pay too little attention to the development of a scientifically informed public opinion. There lies, therefore, at the root of any national scientific policy a complex problem of education; to that I may return later, but first I would like to consider the various ways in which Government is directly involved with science and technology since these must also play an important rôle in the formulation of policy.

Governments are interested in power and power today rests on technological competence. It follows therefore that a government must take a direct interest both in science and technology. The basis of its interest, however, differs somewhat as between science and technology, even though, in some areas at least, the two are closely interwoven. Pure science—and by that I mean the pursuit of knowledge untrammelled by economic objectives – is a branch of culture just like music and the arts and Government must stand to it in the relation of a patron just as it does to these other branches. Government is not, however, a wholly disinterested patron of science. For one thing it knows that pure scientific research can provide the seeds from which later—possibly much later—will come technological advances from which it may derive political and economic power. But Governments have another, and perhaps in the short-term even more important, reason for supporting science. In a technological society it is essential to have an adequate supply of trained scientific manpower capable of applying science and its methods to practical problems. Scientific research carried out in universities and technical institutions has a training function—directly for postgraduates, but also indirectly for undergraduates since first-class teachers in science and technology can only be sustained through the stimulus given to them by research. The vital training function of research in centres of higher education applies both to science and technology, to pure and to applied research both of which are pursued in such centres. It may be well for me to give at this point my definition of these terms. In my view pure scientific research is research aimed at expanding the frontiers of knowledge

without any *economic* objective. Applied research is research which differs only in that it has at shorter or longer range an economic objective; in its philosophy and methods it does not differ from pure research.

It is impossible to state how much money any country should spend on university-type research; examination of published figures does not reveal any simple relationship between such expenditure and economic growth. I will simply say that, in my view, it should be at least sufficient to ensure that the training function of institutions of higher education is discharged adequately to supply the country's need for scientific manpower. I also believe that if research in universities is expanded to the point where it gets divorced from its training function and leads to the setting up of permanently staffed research institutes then it is wrong and it could in the long term destroy rather than promote science. But there are other problems too. Not so long ago scientific research was inexpensive and its support therefore presented Government with few problems. This is no longer true; some areas such as nuclear physics have become enormously expensive and others bid fair to emulate it very soon. Since no Government has unlimited funds at its disposal it must therefore make choices. If it fails to establish its priorities and make choices accordingly, the only result will be a spreading of resources too thinly with a consequent failure to be competitive in any single field. What is needed is a policy for the support of science and such a policy can only be devised as a part of economic policy since its operation will almost certainly determine the number and type of trained scientists and technologists that will become available to meet the country's needs. There is in my mind no doubt that the proportion of our best brains going into one subject is affected by the scale of, and the glamour attaching to the research being done in it. Failure, therefore, to take economic policy into account in determining the areas of science in which major research efforts should be mounted can only lead to frustration, brain drains, and, in the end, industrial stagnation. Government should not, and indeed cannot, control science but it can, and must, control the relative weight of effort in the different areas of science if it is to pursue any coherent economic policy.

There are, of course, areas in which Government is directly concerned with science and technology through its own research and development activities. The first and most obvious of these is defence. Here the case for direct Government involvement is clear, for not only does it set the precise objectives, but it is virtually the sole consumer of the products. Largely for security reasons, Government must bear the main responsibility for both research and development and, in some cases, for production. In defence Government operates very like an industrial corporation; it searches continuously for new and better products and instead of market competition it faces the competition of potential enemies each trying to outpace it in military technology. Its research and development establishments thus have clear cut and frequently changing practical objectives and for this reason they can function effectively. When one looks outside defence, however, the situation is much more complex. There are, it is true, certain

research and development activities with which Government Departments are directly concerned and which for various reasons are not likely to be covered by private industry. Such activities include, for example, roads and communications, health, agriculture, fisheries and control of standards; here Government-owned or -controlled establishments are needed. But in the case of other subject oriented institutes whatever value they may have had in the past has largely gone, since they are, in general, insufficiently geared to industry and industrial needs. Scientific research without the spur of clear-cut economic objectives cannot over a long period remain successful if pursued in permanently staffed institutions unless they also fulfil a training function (as do the universities) and have a continuous throughput of young research workers. Institutions without such a function may seem successful in the period immediately following their creation, but decline always sets in with an aging staff and no challenging aim; even the best direction can only slow up the process. I suppose that what I am saying is that apart from industry, the universities and establishments dealing with specific departmental responsibilities of a public service character only research establishments which are "mission-oriented" are likely to be successful. It should, however, be clearly understood that a Government mission-oriented establishment will normally have a limited life; once its mission is completed it should be disbanded or given a new mission and, as far as is necessary, a new staff to match it; the remainder of the existing staff should be transferred to other activities.

The creation of "subject-oriented" establishments by Governments in the past was associated in many cases with the need to stimulate research and development in industry so as to promote technological innovation. In the United Kingdom the development of the Industrial Research Associations proved to be a more successful method—and indeed most of the forty odd Research Associations are still doing valuable work today. These Associations which are financed partly by Government and partly by firms within the industry concerned, investigate problems of general importance to the industry. Many such problems exist, especially in the older, traditional industries, and there the Associations can be of great value. Not only can they help solve common problems, but they can spread throughout an industry an awareness of the value of research and development and so encourage the growth of such activities within the individual firms in that industry; this latter should indeed be their real goal for in the long run research for industry must be done within industry itself. How to promote technological innovation in industry in the interest of economic well-being is, of course, one of the major concerns of Government. There has been much talk in recent years about the "technological gap" which is said to exist between European and American industry and reasons like size of home market, availability of risk capital and technical awareness on the part of management have all been quoted to explain it. But I sometimes wonder whether, especially in a country like Britain with a long industrial history, and where traditional industries are involved, social factors are not the commonest obstacles to change. Any

major technological innovation is likely to disturb the established social hierarchy both in an industry and the community in which it operates; as a result it tends to be resisted by management and workers alike. It is partly for this reason that the development of the social sciences from their present rather primitive state to something more like exact sciences is so important at the present time. If man is to get the best out of science and technology he must learn to understand himself.

In the task of promoting desirable technological advance Governments can and do employ variable interest rates and other fiscal incentives. In a mixed economy, too, there may well be cases where direct participation of Government in industry by contributing part of the equity and fixed assets of a company is desirable; this could occur where a development is envisaged which is too large or too long-term to be dealt with by one firm or a consortium of firms. The mechanism by which this might be done is something which has been frequently discussed in Britain and elsewhere but no clear conclusions can as yet be drawn on the basis of our present limited experience.

The last century has seen a vastly greater increase in population than ever before in man's history. This is essentially a consequence of the material developments following from the Industrial Revolution. It could have been predicted, for all animals react to increases in food supply and environmental improvements by increasing in number up to the maximum compatible with available food supplies. In the case of man during the past century or so not only has this effect been evident, but he has also demanded—and still demands—all the material comforts which technology has brought in its train. This is why the spectre of world-wide pollution of our environment has begun to worry people; industrial pollution and pollution by human and animal sewage have always been with us, but the combined effects of population growth and technological advances have converted them from purely local to world-wide problems. It is not my purpose here to discuss the need for population control or the prevention of pollution of our environment, but they are vitally important for our future. Moreover, they are clearly matters which concern Government. Only Government can ensure that adequate action is taken in such matters and indeed it seems likely that direct Government involvement—already considerable in such matters as water pollution—will have to be greatly extended within the next few years.

What I have said has necessarily been couched in rather general terms, but it will, I hope, have shown how, directly or indirectly, Government is concerned with science and technology in almost every sphere of its activity from education all the way to foreign policy. That is why scientific policy is so important. It is not merely a policy for the support of science that is needed—it is also the formulation of national policy in the light of scientific knowledge and the implications of scientific or technological discoveries. How are we to ensure that this is done?

The answer to this question has been sought in a variety of way in different countries, which is perhaps not surprising in view of the varying

political systems they exhibit. As yet no final solution has been found but there appears to be a gradual convergence of views which could well lead to a general pattern in a few years time. The United Kingdom was probably the first country to make a major move in the field of science policy shortly after the Second World War. Faced with an impoverished country with an industrial economy distorted by the needs of total war the need to harness scientific knowledge and research to the formulation of Government policy was recognised and in 1947 an Advisory Council on Scientific Policy was set up under the chairmanship of Sir HENRY TIZARD. This Council was set up at Cabinet level directly attached to the Lord President of the Council who was to be responsible for the formulation and execution of scientific policy. Over the years various modifications were made which I need not discuss in detail. I myself succeeded Sir HENRY TIZARD in this office which I held from 1952 until 1964, when a substantial restructuring of our advisory machinery was undertaken with the advent of the Labour Government in that year. Further changes have been made in the UK organisation since then, but the arrangement now in force seems to be approaching some degree of stability. Interestingly enough it bears considerable resemblance to that which was set up in 1947, but there are three important changes. First of all the supreme Advisory Council on Science and Technology covers defence as well as civil science; secondly it reports directly to the Prime Minister rather than to a Minister for Science; and thirdly its chairman is a full-time civil servant who is Scientific Adviser to the Prime Minister. Two subsidiary advisory councils exist—one on technology responsible to the Minister of Technology and one on science responsible to the Secretary of State for Education and Science who is responsible *inter alia* for the Universities. In addition a number of executive departments have their own scientific advisers and advisory councils and it is my personal opinion that this ought to be extended to cover every department of state. One cannot compare one country's organisation for science policy directly with that of another since the outward form, at least, must depend in some measure on the political system in use, but it is true that something not unlike the British pattern is becoming widespread—the United States, for example, has a rather similar arrangement at the uppermost level and the scientific adviser reports directly to the President.

It will be observed that I have referred to advisory bodies on which scientists and technologists—and economists also—serve, but I have not suggested that such bodies should have executive power. This was quite intentional because, although science and technology provide new ideas, materials and machines, the use to which these discoveries are put is a matter for political and not scientific decision. This does not mean that scientists and technologists should be socially irresponsible; it is their duty to make clear to those taking decisions the implications of alternative ways of using new discoveries. It is also proper for them to have their personal views as to the desirability (ethical or otherwise) of any particular application of scientific knowledge. But scientific expertise does not

necessarily imply political wisdom, and in a scientifically informed democracy the political opinion of a scientist is not necessarily more valuable than that of any other citizen. To have decisions in science policy taken by men who were at once first-class scientists and first-class politicians would be ideal, but such men are rare indeed. In general we must see to it that scientists and technologists provide the facts and indicate the logical result of the various possible ways of utilising them to politicians who are sufficiently aware of science to understand the advice they receive and to give it full weight in reaching decisions. In the world of today, as never before, wise Government depends on a synthesis of the exact and the social sciences; how best to achieve that synthesis is perhaps the greatest problem of our time.